First order primal-dual algorithms for total variation methods with applications to image analysis

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Introduction and motivation:

Total variance is introduced in previous classes and your handouts. Total variation minimization is very important in convex variational methods for image analysis (it allows sharp discontinuities in solutions), and it is widely used in image analysis, such as denoising problem, image segmentation problems and so on. While total variation is non-smooth, which limits us to minimize the variational methods with total variation regularization. Chambolle *et al.* [1] proposed a first order primal-dual algorithms for nonsmooth convex optimization problems (including total variation) in image analysis. Pock *et al.* [2] studied diagonal preconditioners for this algorithm introduced in [1]. These papers provides good solutions for the total variation problems.

What to do:

In this paper, we want to use the algorithm to solve several total variation methods in image analysis: total variation denoising, graph cuts and segmentation. Note, Graph cuts is equal to total variation in essence. The segmentation I mention here is total-variation based segmentation.

Aim:

1. Introduce and implement the first-order primal-dual algorithms
2. Introduce and implement the diagonal preconditioning for the first order primal-dual algorithms
3. Use both algorithm to solve total variation denoising, graph cuts and segmentation problems.
4. Compare the algorithms in terms of cost time and accuracy (As the metric may vary due to different methods, I use accuracy to stand for them).
5. If possible, we can implement a parallel version of algorithms

Dataset:

As the worked on problems are all unsupervised (graph cuts and segmentation may need seed point, I do not take it as supervised learning), we can take test images anywhere, and can give some noise by ourselves.

[1]. Chambolle, A., & Pock, T. (2011). A first-order primal-dual algorithm for convex problems with applications to imaging. *Journal of Mathematical Imaging and Vision*, *40*(1), 120-145.

[2]. Pock, T., & Chambolle, A. (2011, November). Diagonal preconditioning for first order primal-dual algorithms in convex optimization. In *Computer Vision (ICCV), 2011 IEEE International Conference on* (pp. 1762-1769). IEEE.